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THE

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ON CEREBRAL PHYSIOLOGY.

No subject is perhaps of more importance and interest to the anthropologist than the researches which are made in ascertaining the functions of the encephalon. The progress made in cerebral physiology generally, will occasionally come under our review; and the approaching publication of a translation of the works of M. Gratiolet, and of Dr. Louis Büchner's *Kraft und Stoff*, will compel us to examine more minutely what is the exact state of our knowledge on this subject. In the meantime, we present our readers with a sketch of our present knowledge on some of the chief points of cerebral physiology, reserving some critical remarks until a future occasion.

Chemical Composition of the Brain. The investigations of Baron Bibra (*Vergleichende Untersuchungen*, etc., Mannheim, 1856) on the chemical composition of the brain of man and the vertebrata, led to the subjoined results. Bibra had always been of opinion that, though the physiological function of the brain did not altogether depend on its fatty constituent, yet that it was mainly conditioned by it. Experiments supported that opinion. Fat is an integral constituent of the brain, being closely connected with its functions, and does not perform the same office in the brain as in other parts of the organism. Even in diseases producing the greatest emaciation, the fat is not sensibly diminished in the brain. The average quantity of fat in eleven adult brains up to 48, amounted to 14·44 per cent. The medulla oblongata always contained most, the *thalami optici* and the *corpora striata* contained least fat. The average quantity of fat in six brains of very old men was but 13·13 per cent. Average quantity of water, 75·66 per cent. Generally speaking, those parts which have most fat have least water, and *vice versâ*. The average of the solid albuminous part amounted to 10·83 per cent., somewhat more than in young individuals, in whom it was 10·09 per cent.

From the circumstance that, after any laborious mental exertion, there are frequently found in the urine large quantities of phosphatic salts, coupled with the alleged fact that in the brain of the adult idiot the quantity of phosphorus is not larger than in the brain of a child, it has been inferred that phosphorus plays some important part in the substance of the brain and its psychical manifestations.

With regard to the quantity of phosphorus contained in the cerebral fat, Bibra arrived at the following results: That the quantity is nearly equal in man, mammal, and bird; that it neither is above the average in the brains of lunatics, nor does it vary much in advanced age. There is, however, more phosphorus in the grey than in the white substance. The quantity of phosphorus seems to depend on the quantity of cerebral fat. Bibra does not think that the quantity of phosphorus is relative to greater or lesser intelligence; though it is certain that the brains of higher animals contain a larger amount of fatty matter, and consequently a larger quantity of phosphorus. The fat has, no doubt, a physiological function as a whole; but it does not follow that the phosphorus specially influences the brain in its intellectual function.

It has been already stated, that the diminution of fat caused by wasting diseases in other parts of the organism does not extend to the brain. Fattening of animals does not increase the amount of cerebral fat. The human brain contains more fat than that of mammals, and the brain of mammals more than the brain of birds. The quantity of cerebral fat is rather less in old than in healthy adult individuals. The brains of mammals cannot be said to contain more water than the human brain; it seems that the lesser quantity of fat is replaced by a larger amount albuminous substance. The brain of birds contains a larger amount of water than that of man and mammals.

Cerebral Circulation. Considering that the brain is not merely the organ of the mind, but the source of energy of a considerable portion of the body, and consequently itself subject to great wear and tear, we might *à priori* assume that a large supply of arterial blood was requisite for its nutrition. And such is actually the case; for this supply is estimated at not less than one-fourth of the whole quantity of blood in the body, which reaches the cranium by four independent channels, derived from the chief trunk of the aorta, namely, the carotids and the vertebral arteries. The force with which the blood is propelled by the left ventricle, may be estimated when we know that after decapitation the blood is projected from the carotids to a distance of five or six feet. But so delicate is the structure of the encephalon, that a circulation through the nervous tissue, in the mode as carried on in other organs, would be incompatible with its functions; hence the division of the large arterial trunks before they enter the brain.

Until a recent period, there prevailed an opinion that the quantity of blood within the cranium was constantly the same. The chief argument in favour of this theory was, that the cranium is a closed hollow sphere, with unyielding walls, filled with fluid. But the cranium is neither altogether unyielding, nor a closed cavity, being, as now proved, connected with the cavity of the spinal canal. Besides this, the cranial cavity is not filled by a simple incompressible fluid, but in addition to the brain by a watery liquid, the quantity of which is subject to constant changes, owing to resorption or secretion, and to afflux or reflux between cranium and spinal canal. Owing to this, and a variety of other circumstances, an expansion or contraction of the cerebral blood-vessels, and consequently an increase or diminution of blood within the cranium, is not merely possible, but must actually occur.

Cerebro-Spinal Fluid. Physiologists differ as to the importance and functions of this substance. Some have considered it as a *post mortem* phenomenon. This is now proved an error, as experiments on animals have abundantly shewn. Magendie, who was one of the first who called attention to this fluid, estimated its average quantity in the adult subject at sixty-two grammes; which Dr. J. Williams (*Lancet*, 1860) considers much below the average. "The clear fluid," observes Dr. Williams, "which sometimes escapes from the ear and nose in cranial fractures, is now proved to be the cerebro-spinal fluid." According to Magendie, the evacuation of this fluid very frequently plunges even the most vigorous animal into a state of complete inertia; and that any change in the quantity or quality of that substance produces well-marked disturbance in the animal economy.

According to Ecker (*Physiologische Untersuchungen, etc.—Physiological Researches in the Cerebro-Spinal Fluid*, 1843), the cerebro-spinal liquid is in constant motion, especially during inspiration. It is accumulated between the arachnoidea and the pia mater; it flows during inspiration into the fourth ventricle, and then through the *aquæductus Sylvii* into the third and the two lateral ventricles. This fluid has been found in considerable quantity in the section of paralytics. It cannot *à priori* be denied that its accumulation in the ventricles may disturb motion. "Perhaps," observes Ecker, "it is owing less to the increase in the ventricles than to its simultaneous diminution in the other parts of the periphery of the hemispheres of the brain and cerebellum. Removal of this fluid in animals by an aperture between the atlas and skull made animals lose their equilibrium; spasms and tremors occurred in the extremities; all which phenomena disappeared on the renewal of the liquid. It is clear, therefore, that the cerebro-spinal liquid is not merely a conservative provision, but influences both physical and psychical phenomena." The pia mater seems evidently the organ which secretes it from the blood on the surface of the nervous centres, and it then passes, by a mechanism unknown to us, into the cavities of the brain. Salt, introduced into the current of the circulation, a portion of the substance is soon found in cerebro-spinal fluid. In an inquest on Sam. Page, who died from excess of spirituous liquors, Dr. Bradley of Boston (U. S.) found on dissection a strong alcoholic odour in the fluid in the ventricles, recognized by every one of the jury. (*Amer. Jour. of Med. Science.*) The cerebro-spinal fluid favours the movements of the brain, and prevents any friction of so tender a body as the nervous pulp against the parietes surrounding it.

The long-pending question about the existence of a central canal in the spinal cord, and the fact of the intercommunication of the sub-arachnoid spaces, have been set at rest by the anatomical investigations of Luschka (*Die Adergeflechte, etc.—The Venous Plexuses of the Human Brain,* 1855). The spinal canal communicates above with the fourth, or, as Luschka calls it, the ventricle of the cerebellum, which again opens into the sub-arachnoid space through an aperture at the end of the *calamus scriptorius.*

The celebrated German physiologist T. Ch. Reil, in whose works many of the germs of apparently recent physiological discoveries may be found, had already conceived the plan of an anatomico-physiological comparison of the cerebral structure and mental activity of animals with that of man, with special reference to race, nation, sex, and age, both in the healthy and morbid state. The following invocation, preparatory to his dissecting a human brain, is so characteristic of this enthusiastic physiologist, that we have no hesitation in quoting it. "Direct my hand, Erato! that I may gently open the shell which covers the noblest production of creation. Arm my eye with acuteness, that it may intelligently examine the Dædalus of organization, which is the birthplace of history, the cradle of art, and the mysterious bridal couch upon which body and soul, the gods of light and the children of nature, carry on their orgies." We may, indeed, safely say that a more complex and marvellous apparatus than the human brain is not to be found in nature. Its delicacy is so great, that six millions of its component microscopic filaments may be packed within a square inch; and yet, how wonderfully are the nervous fibrils interwoven! Will this labyrinth ever be displayed before the eyes of the investigator, like the works in a skeleton clock?

"We find in the brain," says Huschke,* "hills and dales, bridges and aqueducts, beams and vaults, hooks, claws, ammon horns, trees, sheaves, harps, and tuning-forks. No one has yet explained the signification of these singular forms; and centuries may yet elapse before a Copernicus appears,† who may be able to regulate the solar and planetary tracts of our psychical organism."

No one at the present day denies that the nervous system connects all parts of the organism; and that the central organs, and specially the brain, are more or less concerned in psychical phenomena. The great object of cerebral physiology is, therefore, to trace this connection, or, at any rate, to find out how far the mental phenomena are the results or the concomitants of the nervous mechanism; and possibly to deduce some general principles, applicable not merely to the individual nature of man, but to humanity at large.

What are the changes produced by external impressions on the peripheral nerves, and how do they cause perception in some parts of the nervous centre? and how again are, from this centre, the motions determined? Where is the transition from the material impression to the spiritual conception? All attempted solutions leave us in the dark on this perplexing subject. We know the beginning and the end, but the connecting link is as yet hidden from us. The late Sir W. Hamilton, certainly the greatest polyhistor among recent British metaphysicians, considers the various hypotheses held by philosophers relating to the intercourse between mind and body, such as the system of assistance; the pre-established harmony; the theory of a plastic medium, which, partaking of the two natures of body and mind, can act upon both; and, finally, the theory of physical causes, as unphilosophical, simply because of their attempting to establish something beyond the sphere of observation; and he dismisses the subject in the following terms: "The sum of our knowledge of the connection of mind and body is, therefore, this—that the mental modifications are dependent on certain corporeal conditions; but of the nature of these conditions we know nothing."

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* Schadel, Hirn, und Seele (Brain, Skull, and Soul). Jena: 1854.

† Pourquoi l'histoire naturelle n'aurait-elle pas aussi un jour son Newton? Cuvier, Diss. Prél. Rev., p. 4.

All this may be very true. The connection of body and soul is as yet a sealed book; still, science need not give up discussing this or any other question concerning the nature of man. Who can deny the possibility of science ultimately succeeding to trace and establish the laws governing our psychical life, in its connection with the physical organism? or are we to suppose that the connection is not subject to immutable laws like purely physical phenomena? The progress in this direction, and of cerebral physiology in general, has been necessarily slow; still, there has been a progress. The researches of Du Bois Reymond, Matteucci, Brown-Séquard, and other experimentalists, have at any rate made us better acquainted with the physical condition and mechanism of the nervous system. And this is a real progress; for we must first be better acquainted with the corporeal structure, before we can attempt to explain its connection with psychical phenomena.

Willis, who justly may be called the father of modern cerebral physiology, wrote thus in 1683 (*Discourses on the Souls of Brutes*): "Though we can discern nothing with our eyes, or feel with our hands what passes within the secret chamber of the brain, yet may we, by rationally comparing the effects with the working of the machine, at least conjecture what kind of functions are performed in some parts of the head."

Function of Convolutions. Both anatomy and physiology lead to the inference that the convolutions, especially the vesicular grey matter which envelopes them, are connected with the functions of the mind, so that they have been called the intellectual centres. Whether certain convolutions possess those special functions assigned to them by the phrenologists is a different question altogether. A mere alteration of the vesicular grey surface is capable of producing mental disturbance. These convolutions are, according to R. Wagner, already developed in their main proportions about the eighth month; so that the brain of an infant at birth has the principal convolutions as perfect as the brain of an octogenarian. The convolutions differ greatly in individuals; in some they are very complex, and in others poor. The greatest differences occur in the convolutions of the frontal lobes. There are adult brains, which in their disposition resemble that of the fœtus in the seventh month. The frontal convolutions are less developed in the female brain. There are, however, male brains possessing a female type, and *vice versâ*. In most cases of great development of the frontal convolutions, those of the other lobes are equally so. Rich and complicated convolutions are generally considered as concomitants of intellectual power. Most brains of distinguished individuals have exhibited such a structure. The question is, however, far from being settled; inasmuch as in other brains of great thinkers, the convolutions seemed but little complicated. Instances of this kind are cited by Wagner in his latest researches on the functions of the nervous system.*

And here we cannot omit mentioning the remarkable fact, that the brain, at least a considerable portion of it, the very organ which, so to say, converts the impressions into sensations, and would from its delicate texture be *à priori* supposed to be gifted with the highest degree of sensitiveness, is itself insensible; so that it may be sliced off without the animal evincing any feeling of pain. Just as there have been soldiers who have carried bullets imbedded in the substance of the heart, so have there been who have carried bullets in the brain without immediate fatal results; nor have they been much inconvenienced by pain, as proved by the following cases.

William Roberts, surgeon, in Carnarvon, Wales, reported the following case in the *Lancet*:—" Griffith Jones, still living in a small farm on the lakes of Llanberis, lost his eyes by an explosion of gunpowder, in a quarry; a hole was made above the inner canthus of the eye, in the frontal bone, from which a quantity of brain escaped, Mr. Roberts states that he moved the director in every direction, even straight to the cerebellum. Yet the man felt nothing, and completely recovered, with his intellectual faculties unimpaired."

Dr. Badeley (Lumleian Lectures) quotes the case of a boy, who, on a portion of his brain coming away through a fissure in the skull, consequent on violent injury, earnestly requested that it might be sent to his schoolmaster, who had often asserted " that he had no brains."

The following case, brought before the Medical Society of Ghent, is still more curious, for it is gravely stated that the loss of cerebral substance *improved* the intellect. A young man in Ghent lost by a pistol shot two teacups full of brain, and more at subsequent dressings. He lived for two years, with his intelleet vastly improved, having before been of limited intelligence.

Paroisse (*Opuscules de Chirurgie*, Paris, 1806) received after the battle of Landrecies, in the hospital at Soissons twenty-two wounded soldiers. In all of them a considerable portion of the cranium, integuments, and brain, had been cleanly cut off in battle, by sharp swords. All of them marched with their wounds thirty-five leagues, about five leagues per day, to the hospital. Ten of these soldiers, in whom the loss of bone, integument and brain was less, recovered completely within six or seven weeks. The remaining twelve were carried off in about three weeks. In none of these were the intellectual faculties much disturbed.

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* Gottinger, Abhandl. Vorstudien, 1861.

Doubleness of the Brain, and alleged Duality of the Mind. Some eighteen years ago, Dr. R. Wigan published an ingenious little work, in which he endeavoured to prove that each hemisphere is in fact a separate brain, and not only capable of a distinct process of ratiocination, which may or may not be carried on simultaneously in both hemispheres, but that each brain is capable of a distinct volition, thus establishing what he terms "the duality of the mind." The doctor further lays down that in a healthy encephalon one of the brains is almost always superior to its fellow, and thus capable of controlling its vagaries in thought, and preventing its volitions from passing into acts. He appeals to the experience of most persons of being at times conscious of two opposite volitions, so that it has given rise to the ideas of being possessed by a good or evil genius. This is, however, merely the war which the two brains carry on against each other, the stronger brain of course gets the victory. Hence it may be explained why in some cases patients subject to hallucinations are at the same time conscious that they see only phantasmata. It may then be assumed that one hemisphere is in a morbid state, whilst its fellow is in a healthy condition; in other words, one brain is mad, and the other brain is sane. Considering that the destruction of one hemisphere does not necessarily involve the abolition of thought, nor any decisive impairment of the principal intellectual faculties, it certainly seems no exaggeration in maintaining that we have two brains for thinking, as we have two eyes for seeing, and two ears for hearing. But here the following curious questions arise. Do we use both brains at all times, or do we on common occasions use only one hemisphere, as we use only one hand in writing and other handy work? May not the two hemispheres be in a state of alternate activity, so that one hemisphere is torpid whilst its fellow is wide awake? The curious cases of spontaneous somnambulism, in which persons so affected are said to possess "double consciousness" (a term, by the way, very objectionable), that is to say they forget entirely in one state all that has passed in a previous condition, give some countenance to this alternate condition of the two brains. Some have suggested that we only use the two brains when we closely fix our attention on some subject before the mind. Have we the power of suspending the action of one brain whilst we are using its fellow? Such are a few of the speculations to which the duplicity of the brain has given rise.

Huschke, speaking of the corpus callosum, which unites the two hemispheres, says, the larger the commissure the more developed are generally the mental qualities of animals. Men with short or thin commissures are of limited understanding. If the commissure degenerates from disease they lose their memory, or may become idiotic. Treviranus considered the large commissure as the organ of memory, and others as the seat of the soul.

Neither Huschke nor the other authors give any reason for their opinions. Now, without considering the *corpus callosum* the particular seat of any mental faculty, we may fairly assume that upon its perfect integrity depends the combined action of the two hemispheres. Hence we can readily believe that individuals, in whom this commissure is largely developed, can bring the two brains into synergetic action; they can concentrate their thoughts upon any subject before the mind. This power is perhaps the most important element in the faculty of memory. Hence Treviranus was only wrong in calling the commissure the seat of memory, its action being seemingly mechanical. The power of fixing our attention begins to fail when one hemisphere, or may be the corpus callosum becomes impaired. But though we may admit that each hemisphere or brain is an independent organ of thought, it does not follow, as Dr. Wigan assumes, that the mind is dual, or that a separate mind resides in each brain. No doubt there are moments when we seemingly indulge in two different ways of thought, or are apparently impelled by two distinct volitions. This phenomenon is, however, explicable, by the rapidity with which both thoughts and volitions succeed each other, so that we imagine them to be synchronous.

Unconscious Cerebration. Every person, no matter whether or not he pays any attention to his mental process, must have made the observation that he sometimes meets in the street some individuals, who seem perfectly familiar to him, and yet he cannot for the life of him either recollect their names or the circumstances under which he met them. He taxes his memory in vain, until in despair he gives up the task. When lo! after some time all the circumstances appear of a sudden before his mind's eye, though his attention in the interval had apparently been engrossed with some other subject utterly unconnected with that in question. This applies also to more complicated mental operations. Sir B. Brodie *(Psychological Inquiries)* alludes to this subject in the following terms:—"It has often happened to me to have been occupied by a particular subject of inquiry; to have accumulated a store of facts connected with it; but to have been unable to proceed farther. Then, after an interval of time, without any addition to my stock of knowledge, I have found the obscurity and confusion cleared away; the facts seemed to have settled themselves in the right places."

Dr. Carpenter *(Human Physiology,* 608-9), in treating of this phenomenon, observes:—"The entirely new development which the subject is frequently found to have undergone, when we return to it after a considerable interval, cannot be reasonably explained in any other mode than by attributing it to the immediate activity of the cerebrum, which has in this instance automatically evolved the results, without our consciousness. . . . . . It is difficult to find an appropriate name for this class of operation. They can scarcely be designated as reasoning processes, since 'unconscious reasoning' is a contradiction in terms. The designation '*unconscious cerebration*' is perhaps less objectionable than any other."

In the dialogue between Mephistopheles and Wagner (see Göthe's *Faust*) the inquisitive student is strongly advised "to stick to words." But, says the anxious scholar, "there must be a notion attached to the word." Meph. "To be sure there ought; but you must not be too nice about that; for just where our notions are wanting a word will help us out." Now, with all due deference to Dr. Carpenter, we must confess that "*unconscious cerebration*" seems to us an expression utterly devoid of any meaning. We apprehend that in a "cerebration" there must be something which "cerebrates," and something which is "cerebrated;" but, to use a popular expression, we are at a loss to conceive "which is which." But was there really any necessity for coining a new term for that mental process by which the automatic action of the brain, apparently without our knowledge, selects, aggregates, and eliminates facts and events? We think not. To be sure, the assumption of the automatism of the brain smacks somewhat of sensualism,—the modern name for materialism,—which broadly assumes that just as it is the function of the liver to secrete bile, and of the lachrymal gland to secrete tears, so it is the function of the brain to secrete thoughts. But whether we assume that the process is effected by the mind acting on and through the brain, or that the latter acts automatically, the psychical phenomenon of a train of ideas being unconsciously evolved, once the impulse being given by a sensation or an idea, must be admitted as an ultimate fact, explain it as we may. These phenomena appear to us to pertain altogether to the law of association, which extends to all of our ideas, sensual, intellectual, emotional, and volitional. By association, under the laws of resemblance and contiguity in time and place, our ideas are regulated, linked together, and may be called up together. It has been said that it is to the mind what the law of attraction is to matter, drawing together ideas connected by affinities, and repelling others that cannot coalesce. The greatest confusion would prevail in our minds ; our memory would be a lumber room, not a store house, were there not a fundamental principle at work which introduces some order among the myriads of our ideas. It is an automatic process not necessarily attended by consciousness. It is independent of our will; for though we have, in the waking state, considerable control over our association, we cannot altogether emancipate ourselves from its direction. Ideas which we would rather discard *will* start up, in spite of our efforts to suppress them.

And may we not, since it is permissible to theorize, in the absence of positive data, explain the spoken of psychical process in this way, viz., that whilst we use one hemisphere or one brain, in the elaboration of a fresh subject of thought, we leave the other brain to its own automatic action, that is to the association of ideas, in the evolution of which it will sometimes succeed more effectually when let alone than by the interference of the will, for it is frequently this very interference which defeats our object.

The Cerebellum. This organ is anatomically so distinct from the cerebrum, with which it is but slenderly connected at the base, that one would think that there could be no difficulty in assigning to it a special function; yet even here the theories are conflicting. There are comparatively few authors who have assigned to the little brain any participation in the higher psychical manifestations. Amongst modern physiologists we may mention Carus, who considers it as the seat of the will and desires; whilst Jessen deems it as the special organ of the emotions. Dugés *(Traité de Physiologie)* thought it was an organ of the perception of taste and hearing. Gall again, and his followers considered the cerebellum as the exclusive seat of sexual desire. Rolando looked upon the cerebellum as the central source of all voluntary motion. Magendie thought that this organ impels the animal forward, and thus was the antagonist of the *corpora* *striata*, which induce the animal to retrograde. Flourens, Hertwig, and other experimentalists, only looked upon the cerebellum not as the source, but as the regulator of voluntary motions, inasmuch as animals deprived of this organ are still able to move, but cannot maintain their equilibrium. This theory of considering the cerebellum as the co-ordinator of voluntary movements, which had received the assent of most physiologists, is again contested by several eminent authors.

Brown-Séquard also denies that the guiding power has its seat in the cerebellum. "I have ascertained, he observes, that by the irritation they produce on various parts of the basis of the encephalon, that the diseases of the cerebellum or its extirpation in animals cause the disorder of movements, which has been considered as depending upon the absence of a guiding power. In fact the least irritation of several parts of the encephalon, with only the point of a needle, may generate very nearly the same disorder of movements that follows the extirpation of the cerebellum. I have been led to conclude that after this extirpation, or after the destruction by disease of a large or small part of this nervous centre, it is not its absence, but some irritative influence upon the parts of the encephalon that remain unaltered which causes the irregularity of movement."

"The cause of the co-ordination of muscular movements is" (says Schroeder van der Kolk) "situated in the spinal cord, and it has always been incomprehensible to me how any one could ever have referred it to the cerebellum. If the cause of co-ordination lay in the cerebellum no harmonized reflex movements could take place in a decapitated frog. . . . . If the cerebellum were the seat of co-ordination, irregular movements would of necessity ensue, on an irritation of that organ. But in ulceration of the cerebellum, when the irritation is more chronic and not so violent, I have never seen irregular movements arise."

No wonder that the most recent writer on the physiology of the nervous system, Moritz Schiff, an experimentalist of considerable eminence, has arrived at the conclusion, that for the present, the real functions of the cerebellum are altogether *unknown*.

We have hitherto considered the hemispheres as the sole organ of the mind in man. Doubts have, however, long existed against the generally received opinion that the hemispheres properly so called constitute the only sensorium—the exclusive seat of consciousness. Modern experimenters have, therefore, endeavoured to establish the sensorial functions of certain ganglia in the centre and at the base of the brain; others in the medulla oblongata; and, finally, some in the spinal cord.

"I consider," says Lotze (*Medicinische Psychologie*—Medical Psychology, 1852), "the corpora striata, the optic thalami, the tubercula quadrigemina, the pons, and the cells in their neighbourhood, as that series of organs in which the combination of sensual impression, and the excitation of co-ordinate motion take place, and that these parts may exclusively be considered as the 'organ of the soul.' To ascribe to each of these parts its proper functions we possess no exact data, except the blindness which seems to result from injury to the tubercula quadrigemina, and the disturbed co-ordination of motion, in consequence of the destruction of the optic thalami, and of some parts of the cerebellum. To consider so large an organ as the cerebellum the exclusive seat of sexual desire seems to me an absurd idea. I dissent, therefore, from all such fancies as to place intelligence in the cerebrum, the will in the cerebellum, and the emotions in the mesocephale."

Lotze further thinks that the hemispheres cannot be considered as exclusively the seat of intelligence, inasmuch as large quantities may be lost without interfering with psychical phenomena, and that there are instances on record in which the loss of cerebral substance has, after the cure, rendered the mental operations more active, and the temperament more lively than it was before the loss. He considers, therefore, the hemispheres, specially the cortical portion, as a nutrient organ for the nervous principle of the organs of sense. But though they have no direct influence upon sensation and recollection, the hemispheres may in one aspect be considered as an organ of intelligence, because they determine the force and functional capacity of the nerves, and possess thus a great influence upon the energy of sensation, emotion, and temperament. Dr. Carpenter, as is well known, has long advanced the same theory, giving to the above-mentioned structures the name '*sensory ganglia*', instead of *sensorium commune.*

Thalami Optici. From experiments performed to determine their functions, it seems that these bodies are not, as the name implies, essential to vision, for they have been destroyed without any loss of the power of sight. According to Longet the optic thalami seem to have a crossed action upon the voluntary movements. Destruction of the right thalamus has the effect that the animals fall at once upon the left side, and if the left be destroyed a similar debility is manifested in the right side. The removal of either of these thalami may also produce effects similar to those observed in the division of one crus cerebri, namely, a rotatory motion, the animal turning continually round. The real functions of these bodies are, however, not satisfactorily proved; nor is this surprising, as they can neither be isolated nor entirely removed, without injuring the adjoining parts.

The terms *tuber annulare* and *pons varolii* are by many anatomists used synonymously; others apply the latter term only to the transverse fibres forming the commissure between the hemisphere of the cerebellum, and tuber annulare to the projection from the surface of the medulla, which contains a considerable quantity of vesicular matter; hence they consider this part as a special centre of sensation and motion. The experiments of Longet and Flourens show that even after complete removal of the encephalon above the medulla in warm-blooded animals, leaving the pons intact, there still remain indications of sensibility and voluntary motion, which cease on the destruction of the tuber annulare. The animal may still be induced to move by external irritation, but these movements seem rather due to reflex action of the spinal cord than to volition. The tuber annulare is, therefore, by some physiologists, considered as an organ by which impressions are conveyed inward, are converted into sensations, and where voluntary impulses originate, stimulating the muscles to contract.

Tubercula Quadrigemina. These are four round eminences, placed in pairs, two in front and two behind. The anterior pair, the nates, are longer than the posterior pair, the testes. Both pair are solid in the adult, and composed of white matter externally, and grey matter internally. That these bodies are closely connected with the sense of sight can be proved by direct experiment. Section at any point of the optic nerves to which they give origin, between the retina and the tubercles, produces complete blindness, whilst injury or destruction of the tubercles themselves produce the same effect. Besides being the nervous centres for the perception of light, a reflex action takes place through them to the iris, to regulate the quantity of light admitted to the eye, by the dilation or contraction of the iris. Dr. Laycock (*Mind and Brain*) dissents from this. "It is far more probable," he observes, "that the tubercula quadrigemina belong to the medulla, and may be considered to be co-ordinating structures for the substrata of the muscles of the special senses, including touch. In the mole, with rudimentary optic nerves, these tubercles are of immense size. This fact is of itself sufficient to disprove the theory as to the functions of these bodies."

Corpora Olivaria. Dugès (*Physiol. Compar.*, 1838,) observed:— "The olivary bodies possess another interest, as nervous centres. It should be noted that the olivary bodies are more voluminous in man than in any other animal, and that the nerves of the pharynx, larynx, and the tongue issue from the olivary fasciculi, which by the mediation of the hypoglossus thus act on enunciation."

Van der Kolk says:—"Immediately after I had discovered the special fasciculus connecting the corpora olivaria with the nucleus of the hypoglossus I suspected that the very delicate combinations of motions in the human tongue, in articulation and speech, might afford an explanation of the much greater size of the olivary bodies, and of the more intimate connection with the nuclei of the hypoglossus. For speech and the articulation of words require such a multitude of varying combinations of its muscular movements, that it cannot appear strange that two auxiliary ganglia* should be required for the performance of these functions." That the corpora olivaria are organs for the articulation of the voice is no mere conjecture, but confirmed by facts, several of which are cited by him.

From the intimate connection existing between the facial nerve and the olivary bodies, as shown by Retzius (*Müller's Archive*, 1836), the olivary bodies may also be considered as central organs for the mimic expressions in the countenance.

Semicircular Canals. The experiments performed by Flourens on these organs presented the following phenomena:—Section of the horizontal semicircular canal in a pigeon induced a tendency to turn to one side; section of a vertical canal was followed by a violent vertical movement of the head; section of the anterior vertical canal caused the animal to make continued forward "somersaults." Flourens hence concludes that the nerve supplying these canals does not minister to the sense of hearing, but to the direction of the movements of the animal.

In the sitting of the Academie des Sciences, Feb. 17, 1862, Flourens refers to this subject as follows:—"There are but four principal movements in man; from right to left, from left to right, backwards and forwards, each of which corresponds only to the direction of a semicircular canal; the movements from right to left, and from left to right—to the two horizontal canals, one right and the other left. The movement backward to the antero-posterior canal; the movement forward to the antero-anterior canal. These great phenomena, not yet explained, have engaged my attention for thirty years, and I trust I shall succeed in fathoming them."

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* The accessory olivary ganglia, discovered by Stilling, appear to be the centres for the process of deglutition.

These experiments, showing that there is a constant relation between the direction of each semicircular canal and the direction of the movement have been repeated by Brown-Séquard, and recently by Czermak; the former concludes that the auditory nerve is a veritable centre. Flourens does not say that the cause of the movement lies in the canals, but lies farther off in the encephalon.

The Pineal Gland, which has derived its name from resembling the cone of a pine, and has, from its central position in the brain, been considered by Descartes as the throne of the soul, has long lost caste, since it was found that the sand contained in it is not merely found in the brains of idiots but in the brain of every adult. Nor is the calcareous substance peculiar to the pineal body, but is found in other parts of the cerebrum, and from its resemblance to starch corpuscules, termed by German physiologists *corpora amylacea*. Indeed by some physiologists the pineal body is not considered to consist of nervous tissue at all, but is like the pituitary body, formerly believed to discharge its excretions through the nostrils, and thus to clear the brain, simply placed among the ductless glands. It is scarcely necessary to state that the functions of these bodies are altogether unknown.

The Medulla Oblongata. "Of all parts of the human body," says Schroeder van der Kolk* (p. 87), "there is not one which is of so great moment to the existence and continuance of life, and to the maintenance of the most different and important functions of the system, uniting in a small space, and, as from a central point, directing so much that is various in aspect and really diverse as the medulla oblongata. . . . . Here is, in fact, the nucleus and the central point, whence most phenomena proceed; *here the seat of perception or sensation seems to lie;* violent pain, by reflex action here, produces groaning; here reflex movements pass over to the other side; here is the centre of automatic respiratory functions and of deglutition; hence the nervus vagus derives its remarkable influence upon the heart; and finally, an irritated condition of this part produces excitation of the sexual organs, and even appears to have some influence on the action of the kidneys. That the medulla oblongata is the seat of perception can scarcely any longer be a subject of doubt. Not only is it known that the brain itself is insensible, but while the nerves of sensation in the spinal cord pass upwards, the trigeminus descends to the medulla oblongata, *that is, to the seat of perception.*" (Page 93.)

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* On the Minute Structure and Functions of the Spinal Cord and Medulla Oblongata. Translated by W. D. Moore. London: 1859.

But, strange to say, whilst Van der Kolk considers the medulla as *the* seat of perception and sensation, he invalidates his assumption in his remarks "on shrieking"—"There are, in fact, many involuntary actions, which we ordinarily regard as voluntary; for example, shrieking with pain. This shrieking appears to be merely the effect of a reflex action on the upper part of the spinal cord, or medulla oblongata. . . . . Hence it follows that in vivisections so many incorrect inferences are drawn as to feeling or perception in animals. If the brain is cut off above the pons varolii, and the fifth pair of nerves be strongly stimulated, the animal will cry out, *although without consciousness, without perception, and without feeling of pain.*" (Page 77.)

Here we may well ask, if the medulla, and not the brain, is the seat of sensation, how does it come to pass that the removal of the hemispheres abrogates sensation, though the medulla remains intact? The above fact would rather lead to the inference that the seat of perception is in the hemispheres, and not in the medulla. We simply draw attention to this glaring contradiction, without in any way denying that the medulla may be a centre of sensation and motion, specially in animals possessing no brain, properly so called. But not merely the medulla oblongata, but the spinal cord, properly so called, has been considered as a real sensorium.

Sensorial Functions of the Spinal Cord. Many observations have abundantly proved that animals may feel and will after the removal of the hemispheres. It is also remarkable that this removal does not produce the same effect in all animals. Thus, rabbits and guinea pigs were seen to run about after the operation, and the latter are even said to defend themselves, when irritated.

The clearest proofs of sensation and volition are, however, exhibited by reptiles. "Twenty-four hours," says Volkmann (*Wagner's Handwörterbuch*, i., 579), "after I had removed the large hemispheres from a frog it skipped about in the room, endeavouring to conceal itself behind a chest of drawers, and though pushed back several times with the hand or foot, it always returned. Placed into a pot it did not spring forward, but upwards, as if it saw the aperture. Motions of this kind cannot be called reflex, for such actions an excitation is requisite, which primarily proceeds from the periphery to the centre, and secondarily from the centre to the periphery."

A large alligator, four feet long, being decapitated, the headless trunk, as on many former occasions, performed numerous actions, indicative of volition, sensation, and intelligence. The body curved in a manner so as to recede from the offending agent, and the limbs were directed so as to remove it. From its actions, far more impressive than words, it was evident that it judged accurately, as to the degree, duration, and place of painful or painless impressions. (*Dr. Dowler on Nervous Action.*)

E. Pflueger* has published a very interesting monograph " on the sensorial functions of the spinal cord," not only in reptiles but in mammals, and also in man. This theory has only received a partial assent from physiologists.

The Vital Knot (point vital, nœud vital). There is a small **V**-shaped spot of grey substance in the medulla oblongata, resulting from its bifurcation, which is by Flourens pointed out as the centre of life, because instant death is the consequence of its destruction.

Dr. Brown-Séquard, however, considered that Flourens has erred, in ascribing this function to this part, inasmuch as the removal of the "nœud vital" does not immediately produce death, nor is voluntary motion and sensation instantly destroyed.

Flourens replies :—"Physiologists have asked me to indicate the precise spot of the 'point vital.'" I answered, "the point vital" is indicated by the **V**-shaped gray substance. They asked me for an external mark, and I gave it. But I never imagined they would take the external mark for the spot itself. It seems, however, that some have committed this mistake; they removed the **V**-shaped grey substance, and were astonished that the animal did not die. The **V**-shaped substance has nothing to do with the "nœud vital," which is situated beneath it. The "nœud vital" is double, as every thing is double in the nervous centres. In order that life should cease, both halves should be divided to an extent of two millimetres and a half each, five millimetres for the two. A transversal section, deep enough, of five millimetres at this given spot, is sufficient to destroy life at once.

From the conflicting opinions entertained by physiologists, in regard to the function of most parts of the encephalon, it cannot but be admitted, that despite of numerous experiments, cerebral physiology is still in its infancy. The most essential requisite is, no doubt, in the first place, a microscopic anatomy of the brain, which is far from being complete; so that Gratiolet, one of the most eminent cephalotomists of the day, says—" Let us confess that in our ignorance of the true structure of the medulla, the peduncles, and the optic thalami, the question is abandoned to the speculations of physiologists." How long it may be before cerebral physiology shall acquire a firm basis, and reach that state of perfection which may enable us to solve any of the mooted problems, we cannot at present say. In the mean time, we must continue searching for corporeal parallels to psychical manifestations, and collect all possible information relative to cerebral structure, both of individuals and of the different races of mankind.

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* Die Sensorischen Functionen des Rückenmarks. Berlin : 1853. See also G. H. Lewes' Physiology of Common Life, and papers read before the British Association 1858, for the details of a theory generally in accordance with that of Pflüger.

SEEMANN ON THE INHABITANTS OF THE FIJI ISLANDS.

By A. A. FRASER, Esq., F.A.S.L.

It is somewhat singular that so long an interval should have occurred between the revelation of the wonders of the Pacific by Captain Cook —its practical discovery in fact—and the occupation, for colonization or commerce, of certain islands and groups of islands, which he proved to contain all those elements which can be welded into wealth and prosperity. It is true that the famous Botany Bay was examined a few years after the great navigator had visited it,—the spot of his landing being marked by a plate and inscription,—but more than half a century from that date passed before the first emigrant ship ran into Queen Charlotte's Sound, New Zealand, with a number of settlers to occupy a country with which Captain Cook was delighted, and which both the Americans and the French thought of colonizing before us.

The aborigines of Australia having familiarized Europeans with their manners and customs, the white rovers soon faced the feared and long-dreaded New Zealander, or Maori, and anchored in his harbours, fished on his coasts, ascended his rivers, and soon boldly ventured on more intimate relations. It was bold spirits who colonized Australia, and the boldest of them who settled amid the can-